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AD NUMBER
AD016454
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A.D. 164 54

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TWENTY-NINTH

PROGRESS REPORT

OF

THE FIRESTONE TIRE & RUBBER CO.

ON

105 MM BATTALION ANTI-TANK PROJECT

Contract No.
DA-33-019-ORD-33 (Negotiated)
RAD ORDTS 1-12383

THE FIRESTONE TIRE & RUBBER CO.
Defense Research Division
Akron, Ohio

DECEMBER, 1952

CONFIDENTIAL

INDEX

ABSTRACT

An inventory of recoilless rifles and mounts, manufactured by Firestone, for both the BAT and ONTOS projects, is presented. Proposed design changes on the T137E3 rifle are discussed and the features of two new mounts, in process, are given. Tests with a special do :ble-base powder, in four web sizes, are reported.

A group of T119 projectiles were fired from a T19 recoilless rifle at Erie Ordnance Depot. The firing data are presented. Tests were conducted with the T119E11 projectile being fired from a 105mm howitzer. Strength tests of the projectile, charge development studies and flight tests (all fired from M2A1 howitzer) are discussed and test data are presented. A program is presented for continuing the development of the T119 projectile and the phases to be investigated are discussed. An accounting of T119 projectile shipments is given.

Four phases of penetration studies were investigated during this report period. They are: the effect of standoff on machined and drawn liners, the effect on penetration of internal tee configuration, the effect of riser material in loading Comp B and the effect of tee material. The test data are presented and analyzed.

Tests were made with T222E5 fuze base elements for explosive train check and for investigating detonator safety. Comparison tests were made with the T222E5 and T208E5 base elements. Five penetration assemblies using DRC439 fuzing systems were fired. The test details are given and discussed.

THE WEAPON SYSTEM

An inventory of recoilless rifles and mounts manufactured by Firestone for the BAT and ONTOS projects is presented in Table I.

Table I
Inventory of Recoilless Rifles and Mounts
Manufactured by Firestone for BAT and ONTOS Projects

Rifle or Mount	Location	Comments
T137E3 Rifles		
Ser. No. 1	Fort Benning	BAT Evaluation Test
2	Fort Benning	" " "
3	Fort Knox	T165 ONTOS Ser. No. 5
4	Fort Knox	T165 ONTOS Ser. No. 7
5	Aberdeen Proving Ground	Engineering Test
6	Fort Benning	T166 ONTOS Ser. No. 2
7	Fort Benning	T165 ONTOS Ser. No. 6
8	Fort Knox	T166 ONTOS Ser. No. 5
9	Fort Benning	T165 ONTOS Ser. No. 6
10	Fort Benning	T166 ONTOS
11	Fort Knox	T165 ONTOS Ser. No. 7
12	Not Completed	
13	Aberdeen Proving Ground	To replace No. 5
14	Not Completed	
15	Erie Ordnance Depot	For Acceptance Test on T152E4 No. 6
T137E2 Rifles		
Ser. No. 1	Akron	Used for spare parts
2	Akron	Erie Ordnance Depot for proof facility.
T137E1 Rifles		
Ser. No. 1	Aberdeen Proving Ground	To be returned to Akron
2	Akron (E. O. D.)	
3	Aberdeen Proving Ground	To be returned to Akron
4	Aberdeen Proving Ground	Sent to Watertown Arsenal for study. To be returned to Firestone on completion of study.
5	Akron	
6	Akron	
7	Akron	
8	Akron	Returned from Fort Benning
T137 Rifle		
Ser. No. 1	Destroyed at Erie Ordnance Depot	
T152E4 Mounts		
Ser. No. 1	Fort Knox	T165 ONTOS Ser. No. 5
2	Fort Benning	T165 ONTOS Ser. No. 6
3	Fort Benning	T166 ONTOS Ser. No. 2
4	Fort Benning	T166 ONTOS
5	Fort Knox	T165 ONTOS
6	Erie Ordnance Depot	Acceptance Test
T152E5 Mounts		
Ser. No. 1	Fort Benning	BAT Test
2	" "	" "
3	Aberdeen Proving Ground	Engineering Test
T152E3 Mounts		
Ser. No. 1	Akron	Returned from Fort Benning
2	Akron	Converted to E4
3	Akron	Converted to E4
4	Erie Ordnance Depot	
T152E2 Mounts		
Ser. No. 1	Aberdeen Proving Ground	To be returned
2	Akron	Scrapped
T152E1 Mount		
Ser. No. 1	Akron	Scrapped
T152 Mount		
Ser. No. 1	Akron	Scrapped

The T137 Rifle

Excessive gas leakage at the breakdown joint of the T137E3 rifle was reported during the accelerated tests conducted at Fort Benning. A study of firing records shows that this reported excessive leakage occurs only on rounds fired with short cases, where the case does not cover the breakdown joint. Several designs for sealing this joint are under consideration and it is expected that a rifle will be modified for testing within a month.

A selective breakdown joint is also under consideration for this rifle. Such a joint would permit the rifle to be removed from the mount cradle either in one piece or as separate chamber and barrel.

The T152 Mount

Two new mounts are being manufactured. The T152E6 consists of the T152 E5 top carriage assembly mounted on a two wheeled aluminum tripod. The T152 E7 mount consists of an aluminum top carriage assembly mounted on the two wheeled tripod of the T152E6 model. Castings are promised for delivery on or before January 10 and fabrication will proceed as rapidly as possible thereafter.

Propellent Evaluation

Double-Base Powder

Tests made with a special double-base propellent (in four web sizes) were reported in the Twenty-Eighth Progress Report. It was found that below a certain temperature there was an increase in pressure with decreasing temperature. It was not known whether this abnormal behavior was due to grain shattering or to poor ignition.

Two web sizes of the double-base propellent were retested using T88E1 primers instead of the M57 primers used in the previous tests. The program was discontinued after the 0°F firings because of poor ignition. At 0°F there was a delay of up to 1 second after the percussion cap fired before the round went off. The data are given in Table II. No further work with this powder is planned.

Table II
Double-Base Propellents

Lot and Web	Temperature (degrees F)	Chamber Pressure (lb / sq in)	Velocity (ft / sec)
PA-E-9876	70	9,700	--
.034 in.	70	10,400	1688
	0	8,900	1612
	0	9,100	1627
PA-E-9877	70	8,300	1655
.037 in.	70	8,800	1649
	0	8,400	1610
	0	8,200	1549

Notes:
1. Primer was T88E1
2. Charge 9 lb. 4 oz, rifle T137E1, projectile, inert slug.

T138 PROJECTILE

As presented in the future program of the Twenty-Eighth Progress Report a study was made to determine the interior configuration of the tee which will permit satisfactory penetration performance. The test results are given in the Penetration Studies section of this report.

The study planned to investigate the effects of spin rate and center of gravity location is scheduled as follows:

No. of rounds	C.G. Location In. from base	Twist	Range (yds)
* 10	5.25	1/160	1500
10	5.0	1/80	1000
10	5.0	1/120	1000
10	5.0	1/160	1000
10	5.0	1/200	1000
10	5.0	1/80	1500
10	5.0	1/120	1500
10	5.0	1/160	1500
10	5.0	1/200	1500

* To complete data already obtained with T138E57 projectiles with a 5.25 in C. G. at 1/80, 1/120 and 1/200.

Accuracy of the T119E11 When Fired From the T19(M27) Rifle

All of the early test firings of T119 projectiles were conducted using a T19 (M27) rifle, modified by reducing the chamber volume to about 500 cu. in. by means of a chamber liner and by enlarging the vents to provide a proper recoil balance. The modifications were made so the internal ballistics of the system would be similar to those of the BAT weapons. The accuracy of the T119 projectile from the modified system was satisfactory, and it was believed that good performance could also be obtained from an unmodified M27 rifle.

During this report period, a group of T119E11 projectiles were fired at Erie Ordnance Depot to determine the accuracy from a T19 rifle. The rifle was reconditioned by installing a new M27 breech assembly and by removing the chamber liner. A charge of 8 lb 4 oz of M10,MP propellent, .033-in. web, Lot No. PA-30240 was found to give test slugs a muzzle velocity of 1700 ft/sec. A total of 14 T119E11 rounds were fired at a 12 ft by 18 ft target at 1028 yards. Twelve hit the target. The first round fell short of the target, the second round struck high on the target and the third round, deflected by improperly positioned velocity coils, missed the target. The probable errors of dispersion for the twelve target hits, corrected to a common aiming point, were V.P.E. = ±.46 mil and H.P.E. = ±.37 mil. These results show that the performance of the T119E11 projectile, when fired from the T19 (M27) rifle, is satisfactory. The range data are given in Table III. A new M27 rifle has been ordered and accuracy tests will be continued when this rifle is available at Erie Ordnance Depot.

105 mm. Howitzer Tests

Strength Tests of T119E11 Projectiles

T119E11 projectiles have been fired from a 105mm howitzer, M2A1, to determine the relative strengths of the projectile components. The results of the tests are intended to serve as guides for further development. With increasing gun pressure the first evidence of failure was an inward yielding of the projectile chamber, followed by a similar yielding in the forward portion of the projectile body.

The tail assembly, with the exception of the piston, showed no evidence of failure. In one case, complete rupture occurred at the neck of the piston.

The range data are given in Table IV and the recovered projectiles are shown in Fig. 1. It should be noted that the projectile orifice diameter was varied and that two propellent lots with different powder webs were used.

The projectile is sufficiently strong to withstand a pressure of nearly 20,000 lb/sq in. Rounds 4 and 5 in Fig. 1 were fired at 19,700 and 19,600 lb/sq in respectively, and these rounds show a very slight yielding of the chamber. An attempt was made to compensate for the crushing action of the gun pressure on the projectile chamber, by increasing the orifice diameter, but no marked effect was found.

The difference in the two propellents is especially noticeable. For a given peak pressure the slower M2 powder gives a much higher muzzle velocity.

The results of this test show that the strength of the T119E11 is more than ade-

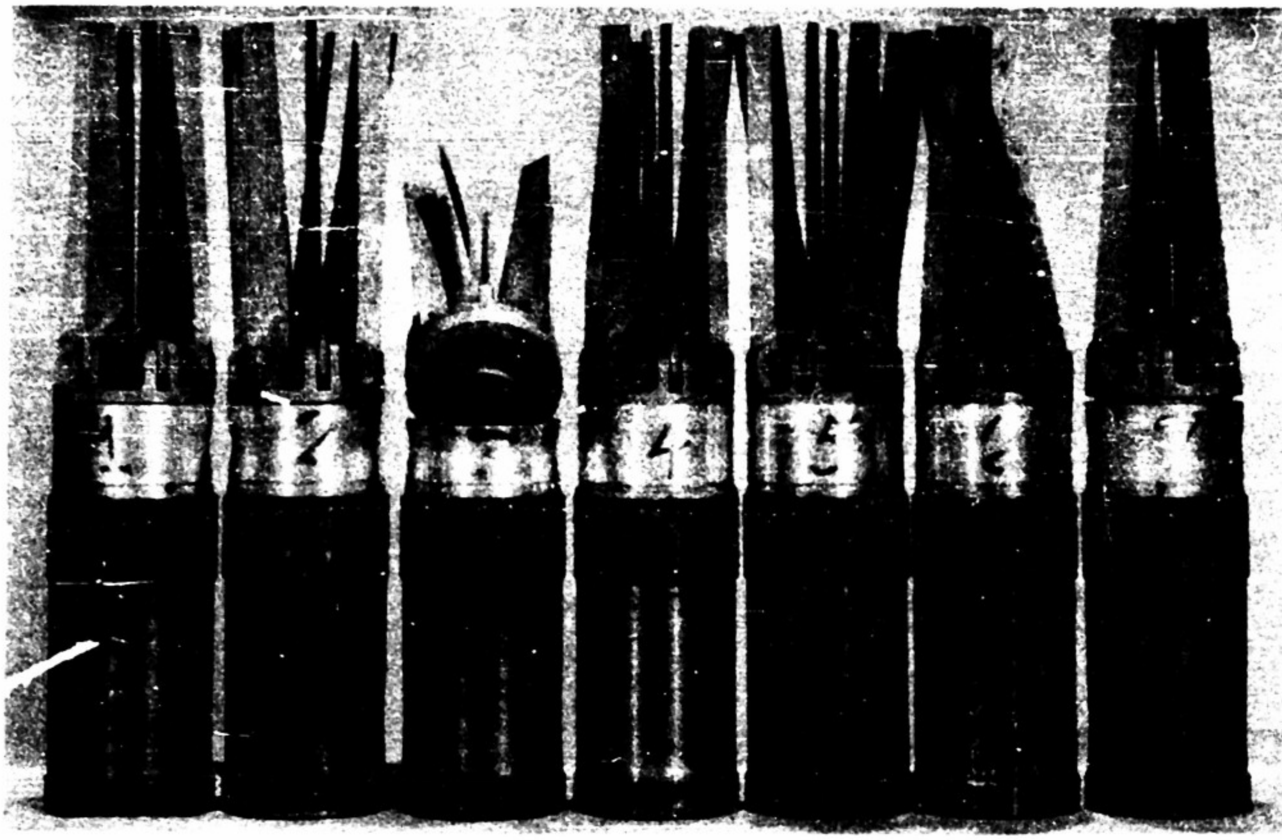

Fig. 1. Recovered Projectiles.
Firings From M2A1 Howitzer.

quate for use in existing BAT weapons, but that the strength of the chamber and body must be increased for pressures above 19,000 lb/sq in. Failure of the piston at the neck indicates marginal strength for this part and suggests a need for improvement. The design of the piston is being changed.

Charge Development and Flight Tests

Following the strength tests described above, a number of T119E11 projectiles were fired in a flight test from the 105mm howitzer, M2A1. A charge development was made and a muzzle velocity of 1700 ft/sec was obtained with a charge of 8 lb 1/2 oz of .026-in. web, M2SP propellent. Details of the charge development are given in Table V.

Nine flight rounds were then fired at a target. The results were poor; only 5 rounds struck the target. The range data for the flight test appear in Table VI.

The data in Table VI show a variation of muzzle velocity ranging from 1635 to 1727 ft/sec with a corresponding spread of chamber pressure. The projectiles were not crimped to the cartridge cases and the variations in velocity and pressure may indicate that some of the projectiles separated from the cases when chambered.

Measurements of the fin spread, taken near the muzzle, and at the target, show that the fins opened too much. Excessive fin spread is attributed to failure of the piston at the neck. This type of failure was previously observed in the rounds recovered from the strength tests described above. It is planned to repeat the tests using crimped rounds and stronger pistons.

T119 Cartridge Development

Projectile Development

Length - As now manufactured and assembled the T119E11 complete round is 39.28 in. long. Although this compares favorably with the 40.8 in. of the M323 HE and M325 WP rounds, shortening the body and ogive of the T119 projectile as shown in Fig. 2 reduces the length to 35.77 in. The material removed may be redistributed to strengthen the body and to move the center of gravity forward.

If shortness itself is desirable, the length of the T119 cartridge could be reduced to about 26 in. by using a shorter, larger diameter cartridge case. This would, however, require a new rifle with an appropriate chamber.

Fins - The performance of the T119E11 is evidence that the choice of the present six-fin configuration was judicious but no study has yet been made to determine the optimum number and size of the fins. Therefore, experiments are planned to test projectiles with fewer fins, and also with shorter fins.

Fuzing - Some preliminary penetration chamber tests (See Section on Fuzes) have been carried out using a plug-in type connector for the base element and have been found satisfactory. A new nose element with a similar type of plug-in connector will be tested soon. This type of connector simplifies assembly of the projectile and permits easier replacement of defective parts.

Multi-Piece Fabricated Cartridge Case

A multi-piece fabricated case is being designed to meet the request for an alternate to the cold drawn T53E1 case currently used with T119E11 rounds.

Satisfactory multi-piece fabricated cases (T53 as shown in Fig. 3) were manufactured and used successfully for T119 ammunition fired in the T137E2 rifle. Several hundred cases are still available but cannot be used in the present BAT rifles. However, there is no reason for believing that satisfactory multi-piece fabricated cases cannot be made as an alternate for any one of the cold drawn steel cases being used in 105mm recoilless rifles. The cost of making a limited number of fabricated multi-piece cases will be considerably greater than the cost of modifying the cold drawn M32 case already in large scale production. A production study is now being made to compare the capital equipment and tooling costs and the piece cost for fabricated multi-piece and drawn cases, produced at the rate of 100,000 units per month.

Relaxation of Tolerances

Experience with the T119E11 round has shown that some of the close dimensional tolerances in the fin-opening mechanism are not required. The asymmetries from tolerance variations which would ordinarily contribute to poor accuracy are apparently minimized by the slow rolling motion which is imparted to the projectile by the canted fins.

A critical study of the limit to which tolerances can be relaxed is planned. Such a study will involve accuracy firing of groups of rounds with known variations in dimensions of the fin assembly.

Projectile Shipments

Type	Date Shipped	Shipped To	Quantity
T119E11 Live	12-20-52	Picatinny Arsenal	100
T119E11 Inert	12-31-52	Aberdeen Proving Ground	30
T119E11 Inert	1-6-53	Frankford Arsenal	50

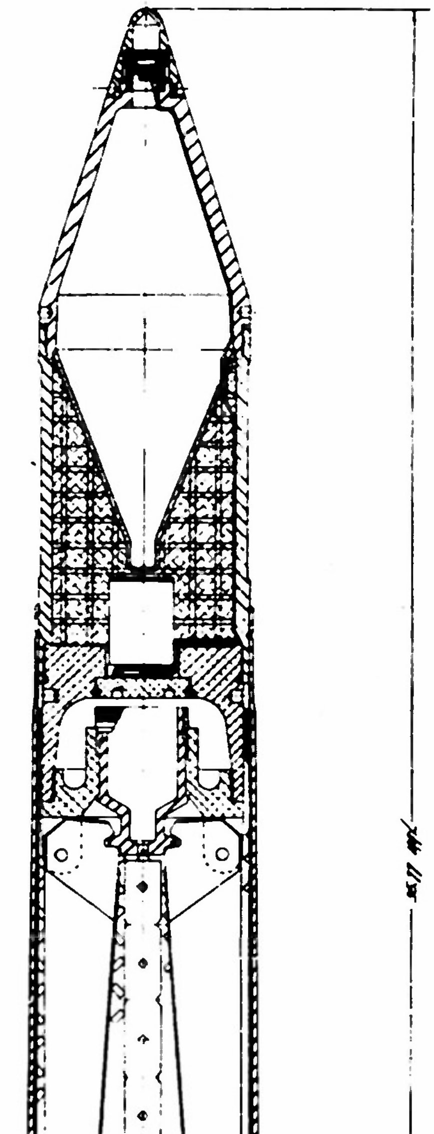

Fig. 2. Short T119 Round.
For T170 or M27 Rifle.

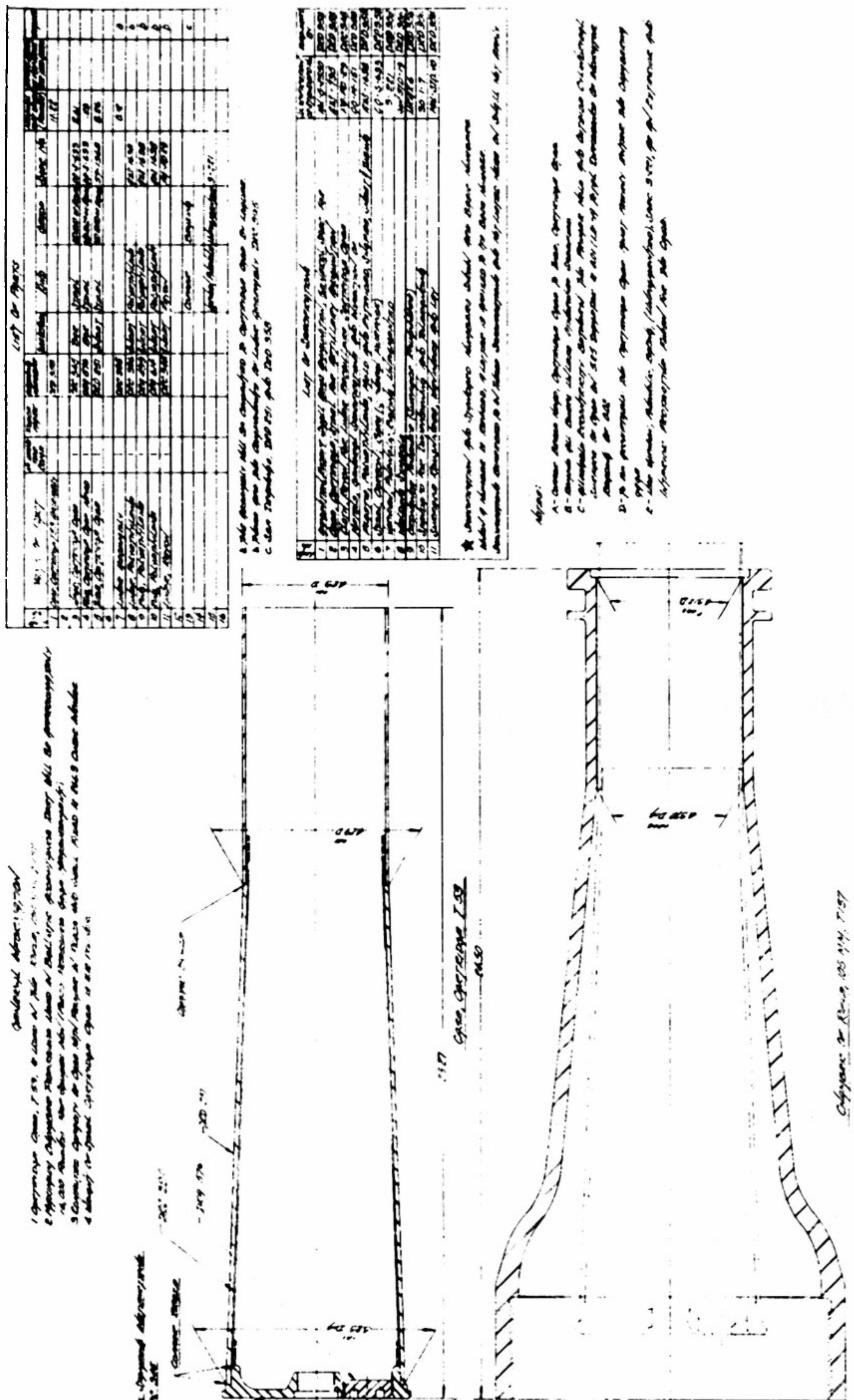

Fig. 3. Multi-Piece Fabricated Case.
T83, Firestone Drawing No. DRD358.

Table III
Accuracy Range Data
To Test Accuracy of T119E11 Projectile From T19 (M27) Rifle

Date December 14, 1952 Program T119C2

To Test Accuracy of T119E11 Projectile From T19 (M27) Rifle.

PROJECTILE

Model T119

Type E11

Weight (Nominal) 17.52 lb

C.G. Location ______

Bourrelet Dia.(Nom.) 4.130 in. -.002

Special Features .196" Orifice Dia:

Screen Distances 109.58' 1st Screen 22.26' 2nd Screen

TEST GUN

Model T19 E6

Type 105 mm Recoilless

Length of Tube 106 in.

Twist of Rifling 1-20

Sighting Equipment M17 & Gunners Quadrant

Bore Dia. (Lands) 4.134 +.001

Case - M32 with Rear Loading Plug.

Primer - M57

Liner - Polyethylene Sleeve

MISCELLANEOUS DATA

Range 1028 yds.

Propellant

Type M10 MP web .0385 PA 30246 Charge Wt. 8 lb 1 4 oz

Proof Director E. Huffman

Observers C.M. Cox, V. Lucas, M. Tennis.

Round No.	Proj. No.	Proj. Weight	Wind Vel. & Dir.[a] mph-deg	Chamber Pressure Piezo	M3 Int. Copper	Muzzle Velocity Instr.	Actual[b]	Elev. (mils)	Azimuth (mils)	Position of Hit (in.) Vert.	Horiz.	Corrected Position of Hit - mils Vert.	Horiz.	Fin Spread on Target		Clearance Front	Rear	Observations
4321	slug		DRC 510			—	—	WARM-UP ROUND										
4322	slug		DRC 610			1626	1684	WARM-UP ROUND										
4323	slug		DRC 610			1606	1664	WARM-UP ROUND										
4324 -1	X 250		14-221	—	8000 7900	1616	1644	230	-2	Low - MISSED TARGET								Good flight
4325 -2	X 241		14-223	—	7000 7800	1653	1681	250	-2	+72	-15½							" "
4326 -3	X 242		15-219	7,500	8000 7600	1645	1673	235	-2	Low & Left - Missed Target - Struck Velosity Coil								
4327 -4	X 251		15-219	—	8200 —	1651	1679	23.6	-2	-16	-14½	-.44	-.40	10				Good flight
4328 -5	X 265		14-220	7,600	9100 —	1652	1680	23.5	-2	-11	-28	-.30	-.78	10¾				Slight Procession
4329 -6	X 254		15-216	8,100	7700 —	1625	1653	23.5	-2	+1½	-46	+.04	-1.28	10				Good flight
4330 -7	X 244		14-215	8,100	7600 7800	1658	1686	236	-2	-27	-33½	-.75	-.93	10½				" "
4331 -8	X 245		14-217	8,100	7500 —	1647	1675	236	-2	+5½	-46¾	+.15	-1.30	6½				" "
4332 -9	X 246		12-218	8,300	6700 —	1645	1673	236	-2	-12	-30	-.33	-.83	10¾				" "
4333 -10	X 249		12-215	8,200	7200 7800	1654	1683	236	-2	-30	-48	-.83	-1.33	11¼				" "
4334 -11	X 248		14-214	8,300	7400 8200	1656	1684	23.6	-2	+30½	-88	+.85	-2.44	10½	Small Yaw			" "
4335 -12	X 252		14-212	8,300	7400 —	1663	1691	236	-2	-24½	-56½	-.68	-.56	10¼				" "
4336 -13	X 253		13-209	8,500	7800 8100	1666	1694	23.6	0	-46½	+25½	-1.29	-1.29	14	Small Yaw			" "
4337 -14	X 247		13-210	8,500	8300 8000	1660	1688	23.6	0	-50	+86	-1.39	-1.00	10½				" "

a Wind direction measured in degrees clockwise from the line of fire.

b Retardation Factor = .194 ft/sec/ft.

Center of Impact $\bar{V}$ = -.38; $\bar{H}$ = -1.13 mils

Probable Error - Vertical ±.46 mil

Probable Error - Horizontal ±.37 mil

} for 12 rounds

Signed - O. Miller.

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Table IV
Strength Tests of T119E11 Projectiles
Fired From a Howitzer

Date 12-11-52 & 12-11-52 Program ________

STRENGTH TESTS OF T119E11 PROJECTILES FIRED FROM A HOWITZER.

PROJECTILE
Model T119
Type E11
Weight (Nominal) 17.52 lb
C.G. Location ________
Bourrelet Dia (Nom.) 4.130 -.002
Special Features Blunt Nose, Variable Orifice Diameter

Retardation Factor = 40 ft/sec/ft.

MAGAZINE TEMPERATURES
Max. 70°F
Min. 70°F
Present 78°F
Loading Room 76°F
Ambient 36°F

TEST GUN
Model M2A1 Howitzer
Type 105 mm
Length of Tube 8L67 in.
Twist of Rifling 1-20
Sighting Equipment M17 Elbow Telescope & Boresighted
Bore Dia. (Lands) 4.134 in.
Case · 105 mm M14 with rear plug loading.
Primer · M1B1A2

MISCELLANEOUS DATA
Range Recovery Box.
Propellant
IND 12033 Type M1SP web .019 Charge Wt. Varies
17312 Type M2SP web .025
Proof Director E. Huffman
Observers C. Engebretsen

Round No.	Proj. No.	Proj. Weight	Powder Charge (lb-oz)	Powder Lot No.	Chamber Pressure	Muzzle Velocity Instr.	Muzzle Velocity Actual	Proj Orifice Dia.(in)	Observations
1	X 239	17.62	2-4	IND 12033	22,400		1821	.196	Moderate chamber deformation.
2	X 236	17.53	2-6	"	27,600		1931	.196	Chamber badly deformed; body deformed.
3	X 238	17.52	2-6	"	26,300		—	.221	Chamber broken; body deformed.
4	X 234	17.56	2-9	"	19,700		1776	.196	Moderate chamber deformation.
5	X 237	17.64	2-3	"	19,600		—	.221	No visible deformation of chamber.
6	X 240	17.52	3-10	17312	21,800		1979	.221	Chamber deformed; piston head broken off.
7	X 235	17.53	3-10	"	29,500		2042	.196	Chamber deformed; body deformed.
4290-8	X 224	17.53	2-2	IND 12033	17,400 18,200	1683	1731	.246	Normal functioning and flight; No distortion of projectile body or chamber.
4291-9	X 223	17.53	2-12	"	39,100 40,800		—	.246	Chamber collapsed; body collapsed.

Signed – O. Miller.

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Table V
Charge Development Data
T119E11 from a Howitzer

PROJECTILE
Model T119
Type E11
Weight (Nominal) 17.52 lb.
C.G. Location ______
Bourrelet Dia (Nom.) 4.130 $^{-.002}$ in.
Special Features Orifice Dia = .196 in.

SCREEN DISTANCES
88.75' — 63' — 2633' — Box

MAGAZINE TEMPERATURES
Max. 75°F
Min. 75°F
Pres. 76°F
Loading Rm. 75°F
Ambient 39°F

Date 12-30-52
Program T119C2 CHARGE DEVELOPMENT

TEST GUN
Model M2A1 Howitzer
Type 105 mm
Length of Tube 81.67 in.
Twist of Rifling 1-20
Sighting Equipment Bore Sighted
Bore Dia. (Lands) 4.134 $^{+.001}$ in.
Case - 105 mm M14 with rear loading plug
Primer M1B1A2

MISCELLANEOUS DATA
Range Recovery Box
Propellant
Type M2SP web .026 in. Charge Wt. Variable
Lot No. 17312
Proof Director E. HUFFMAN
Observers ______

Round No.	Proj. No.	Proj. Weight	Powder Charge lb-oz	Wind Vel. & Dir.	Chamber Pressure	Muzzle Velocity Instr.	Muzzle Velocity Actual	Fin Spread First Screen (in.)[b] 1	2	3	Observations
4363 -1	X273	17.57	3-2		17,600 16,200	1741	1764	10¾	11	10¾	All of these projectiles were fired with conical noses
4364 -2	X269	17.54	3-0		13,900 14,300	1662	1685	10¾	10⅝	10½	Parts of the projectiles were recovered.
4365 -3	X280	17.53	3-4		18,800 18,800	1826	1849	10¾	10⅝	10¾	
4366 -4	X270	17.56	3-½		17,400 17,800	1748	1771	10½	10½	10¾	

a. Retardation factor = .194 ft/sec/ft.
b. Allowable fin spread variation: 10.58 to 10.82 inches.

Signed - O Miller.

Table VI
Flight Test of T119E11 Projectile
Fired from M2A1 Howitzer

Date 1-2-53 Program T119C2

FLIGHT TEST OF T119E11 PROJECTILES FIRED FROM M2A1 HOWITZER.

PROJECTILE
Model T-119
Type E11
Weight (Nominal) 17.62 lb
C.G. Location ________
Bourrelet Dia (Nom.) 4.122 -.002 in.
Special Features Orifice Dia =.196 in.

TEST GUN
Model M2A1 Howitzer
Type 105 mm
Length of Tube 81.6 in.
Twist of Rifling 1-20
Sighting Equipment Elbow Telescope & Gunner's Quadrant.
Bore Dia. (Lands) 4.124 +.001 in.

MISCELLANEOUS DATA
Range 1800 yds
Propellant
Type M2SP web .026 in Charge Wt. 3 lb. ½ oz.
Lot No. 17312
Proof Director E. HUFFMAN
Observers M. F. TOOHIG.

Round No.	Proj. No.	Proj. Weight lb.	Powder Charge lb - oz	Wind Vel. & Dir.[a] m.p.h. - deg	Chamber Pressure	Muzzle Velocity Instr.	Muzzle Velocity Actual	Elev. (mils)	Azimuth (mils)	Fin Spread (in)[b] Yaw Cards Near Gun 1	Yaw Cards Near Gun 2	Yaw Cards Near Gun 3	On Target 1	On Target 2	On Target 3	Observations
4367	Slug	17.32	3 - ½	—	14,000	—	—									
4368	Slug	17.22	"	—	14,800	—	—									
4369	X243	17.55	"	6 - 126	13,200	1656	1687	24	0				Missed Target			Erratic Yaw Over Range
4370	X276	17.55	"	7 - 110	15,500	1679	1710	24	0				18½	18½	18	Small Yaw
4371	X272	17.55	"	8 - 130	12,400	1604	1635	24	0				Missed Target			Large Yaw.
4372	X267	17.56	"	5 - 90	16,300	1628	1659	24	0				13½	13¼	12¾	Small Yaw.
4373	X275	17.56	"	6 - 90	12,700	1696	1727	25	0				Missed Target			Poor Observed Flight Characteristics
4374	X277	17.56	"	5 - 75	14,700	1681	1712	25	0	11	11	11	Missed Target			Small Yaw
4375	X274	17.56	"	4 - 45	14,000	1639	1670	25	0				10¾	10¾	10¾	Small Yaw
4376	X279	17.56	"	4 - 75	15,800	1675	1706	24½	0	11	11	11½	15¼	15¼	15¼	Small Yaw.
4377	X278	17.56	"	4 - 55	14,100	1663	1694	24½	0	14½	13	14	10¼	10¼	10½	Small Yaw.

a. Degrees clockwise from North. Angle of fire +15° from North

b. Allowable fin spread variation: 10.55 to 10.82 in.

Signed - W. A. Brown.

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Machined Versus Drawn Liners—Effect of Standoff

Two series of DRB398 copper cones (Fig. 1, Twenty-Seventh Progress Report) were tested to determine the effect of standoff distance upon penetration. One series of DRB398 cones were drawn from copper plate, the second series were machined from hard drawn copper bar. The inspection data for the cones are shown in Tables VII and VIII. The data shown for the drawn cones are representative of the production lot of cones, but do not include the specific cones fired. The penetration data are shown in Tables IX and X and in Fig. 4. The standoff behavior of each of the two series of cones is very similar although there is an indication that the machined cones have somewhat better penetration at the longest standoff. The greatest difference is the much reduced spread of the penetration data for the machined cones. This greater uniformity of performance is attributed to the improved symmetry of the machined liners.

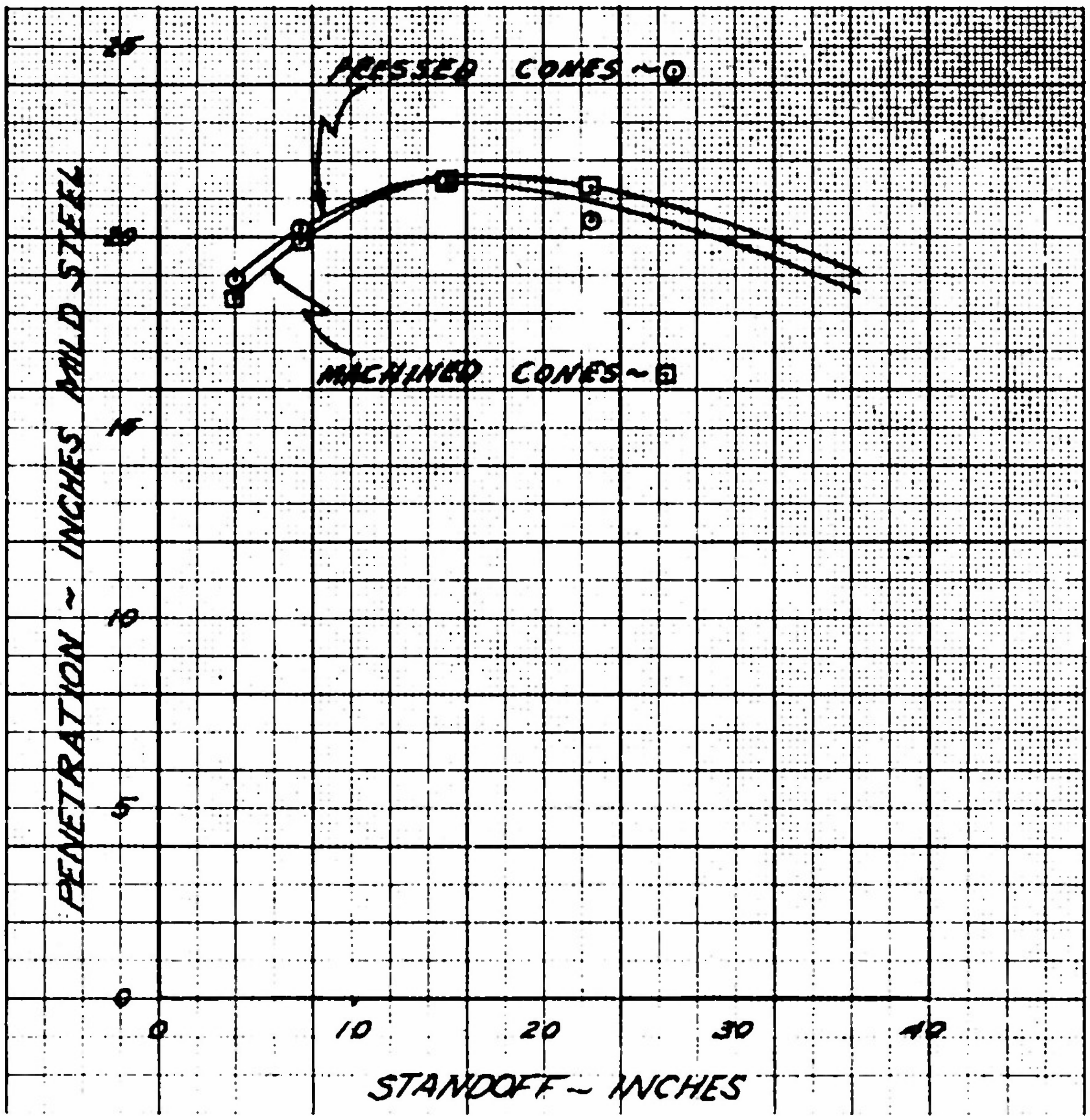

Fig. 4. Penetration Versus Standoff.
Machined and Pressed Cones.

Table VII
Inspection Data For DRB398-6 Liners
(Machined)

Cone No.	Wall Thickness (in.)			Max. Variation W.T.		Max. Wall Waviness		Concentricity	
	Max.	Min.	Avg.	Trans.	Long.	I.D.	O.D.	Lower Datum	Upper Datum
FS-627	.1040	.1020	.1033	.0010	.0020	.0015	.0005	.0030	.0040
FS-628	.1060	.1035	.1051	.0020	.0025	.0030	.0010	.0050	.0030
FS-629	.1060	.1040	.1051	.0005	.0020	.0030	.0010	.0030	.0030
FS-630	.1060	.1030	.1046	.0005	.0030	.0040	.0015	.0030	.0020
FS-631	.1060	.1010	.1036	.0010	.0050	.0040	.0015	.0025	.0030
FS-632	.1060	.1045	.1052	.0010	.0015	.0020	.0010	.0080	.0100
FS-633	.1055	.1040	.1048	.0010	.0015	.0015	.0015	.0035	.0020
FS-634	.1030	.1025	.1029	.0005	.0005	.0015	.0000	.0030	.0025
FS-635	.1050	.1040	.1046	.0010	.0010	.0015	.0000	.0020	.0010
FS-636	.1020	.1000	.1009	.0005	.0015	.0020	.0000	.0030	.0045
FS-637	.1050	.0995	.1023	.0010	.0050	.0050	.0005	.0040	.0025
FS-638	.1090	.1050	.1068	.0010	.0040	.0050	.0005	.0040	.0045
FS-639	.1050	.1040	.1046	.0010	.0010	.0015	.0000	.0050	.0030
FS-640	.1060	.1040	.1048	.0010	.0020	.0025	.0005	.0030	.0030
FS-641	.1060	.1025	.1042	.0010	.0030	.0035	.0005	.0030	.0045
FS-642	.1065	.1050	.1058	.0010	.0015	.0020	.0005	.0020	.0025
FS-643	.1040	.1020	.1030	.0005	.0020	.0030	.0005	.0045	.0045
FS-644	.1065	.1040	.1055	.0015	.0020	.0010	.0000	.0040	.0020
FS-645	.1040	.1010	.1024	.0005	.0030	.0010	.0005	.0020	.0020
FS-646	.1065	.1040	.1053	.0010	.0015	.0020	.0005	.0030	.0015
FS-647	.1020	.1000	.1014	.0010	.0020	.0015	.0005	.0030	.0030
FS-648	.1080	.1050	.1066	.0005	.0030	.0030	.0010	.0030	.0010
FS-649	.1050	.1030	.1043	.0010	.0020	.0015	.0005	.0025	.0030
FS-650	.1050	.1035	.1043	.0010	.0015	.0010	.0005	.0040	.0045
FS-651	.1065	.1050	.1053	.0015	.0015	.0020	.0000	.0055	.0050
FS-652	.1060	.1040	.1051	.0010	.0020	.0025	.0005	.0020	.0030
FS-653	.1065	.1040	.1054	.0005	.0025	.0020	.0005	.0020	.0015
FS-654	.1050	.1020	.1038	.0010	.0030	.0030	.0000	.0080	.0080
FS-655	.1080	.1070	.1077	.0010	.0010	.0015	.0000	.0015	.0025
FS-656	.1040	.1030	.1033	.0010	.0010	.0015	.0005	.0030	.0015
FS-657	.1050	.1030	.1042	.0010	.0020	.0020	.0000	.0020	.0015
FS-658	.1050	.1040	.1047	.0010	.0010	.0015	.0005	.0025	.0015
FS-659	.0980	.0950	.0966	.0010	.0025	.0030	.0005	.0050	.0050
FS-660	.1055	.1050	.1051	.0005	.0005	.0010	.0000	.0025	.0015
FS-661	.1070	.1055	.1061	.0010	.0010	.0020	.0005	.0045	.0030
FS-662	.1045	.1035	.1041	.0005	.0010	.0010	.0000	.0040	.0010
FS-663	.1060	.1015	.1039	.0005	.0045	.0050	.0005	.0030	.0015
FS-664	.1045	.1020	.1031	.0005	.0025	.0025	.0000	.0035	.0030
FS-665	.1060	.1050	.1057	.0010	.0010	.0010	.0005	.0025	.0020
FS-666	.1040	.1010	.1025	.0010	.0025	.0030	.0005	.0035	.0030
FS-667	.1070	.1040	.1056	.0010	.0020	.0020	.0020	.0030	.0020
FS-668	.1030	.1010	.1021	.0010	.0020	.0020	.0010	.0030	.0030
FS-669	.1055	.1030	.1044	.0010	.0020	.0020	.0010	.0035	.0030
FS-670	.1055	.1040	.1049	.0015	.0015	.0025	.0050	.0040	.0040
FS-671	.1050	.1040	.1046	.0005	.0010	.0010	.0005	.0030	.0020
FS-672	.1060	.1040	.1050	.0000	.0020	.0020	.0000	.0035	.0050
FS-673	.1060	.1030	.1049	.0020	.0030	.0030	.0005	.0020	.0015
FS-674	.1075	.1040	.1057	.0010	.0035	.0040	.0010	.0020	.0020
FS-675	.1050	.1030	.1043	.0010	.0020	.0025	.0000	.0020	.0005
FS-676	.1065	.1050	.1056	.0050	.0015	.0020	.0005	.0020	.0010
FS-891	.1070	.1035	.1050	.0010	.0030	.0020	.0005	.0015	.0010
FS-892	.1080	.1035	.1055	.0010	.0045	.0045	.0005	.0045	.0035
FS-893	.1060	.1020	.1040	.0010	.0035	.0035	.0010	.0020	.0025
FS-894	.1045	.1030	.1039	.0010	.0015	.0020	.0050	.0040	.0040
FS-895	.1040	.1020	.1032	.0010	.0015	.0010	.0000	.0035	.0025
FS-896	.1010	.0975	.0994	.0005	.0035	.0035	.0000	.0035	.0070
FS-897	.1035	.1010	.1026	.0010	.0025	.0040	.0010	.0025	.0015
Avg.	.1030	.1053	.1042	.0010	.0022	.0024	.0007	.0033	.0029
Std. Dev.	±.0020	±.0018	±.0018	±.0006	±.0011	±.0011	±.0009	±.0013	±.0017
DRB-398-6	.1000	.1050		.0020	.0060	.0060	.0060	.0030	.0030

Notes:
1. Variation in straightness or thickness of wall shall not exceed .006 in any axial plane.
2. Variation of wall thickness in any transverse plane shall not exceed .002.
3. The indicated measurement at each datum is the total indicator runout of the liner's outside surface relative to the register diameter. The difference between the runout at the two datum planes is an indication of the lack of perpendicularity of the register plane and the liner axis.
4. Lower datum is .484 inch above the base; upper datum 3.202 inches above base.

Table VIII
Inspection Data for DRB398 Liners
Drawn Cones – Lot 3

Cone No.	Wall Thickness - inches			Max.Var.Wall Thick.		Max.Wall Waviness		Concentricity (In.)	
	Max.	Min.	Avg.	Trans.	Long.	I. D.	O.D.	Lower Datum	Upper Datum
Q785	.108	.104	.1062	.0015	.0030	.0025	.0015	.0065	.0070
Q786	.109	.104	.1063	.0010	.0050	.0020	.0015	.0020	.0035
Q787	.109	.105	.1068	.0010	.0040	.0015	.0010	.0020	.0015
Q788	.107	.103	.1049	.0010	.0035	.0020	.0015	.0040	.0025
Q789	.107	.102	.1056	.0010	.0040	.0030	.0015	.0040	.0025
Q790	.109	.105	.1069	.0020	.0020	.0030	.0010	.0025	.0030
Q791	.107	.103	.1059	.0025	.0040	.0040	.0015	.0015	.0020
Q792	.107	.103	.1051	.0020	.0040	.0050	.0020	.0020	.0040
Q793	.107	.104	.1051	.0015	.0030	.0020	.0005	.0040	.0010
Q794	.109	.105	.1070	.0020	.0020	.0020	.0010	.0040	.0030
Q795	.107	.103	.1052	.0020	.0025	.0020	.0005	.0040	.0035
Q796	.107	.104	.1058	.0010	.0025	.0020	.0005	.0030	.0025
Q797	.107	.104	.1052	.0010	.0030	.0020	.0000	.0025	.0080
Q798	.107	.105	.1060	.0020	.0025	.0025	.0005	.0025	.0065
Q799	.108	.104	.1057	.0020	.0040	.0040	.0010	.0020	.0015
Q800	.107	.105	.1061	.0020	.0015	.0020	.0005	.0020	.0055
Q801	.107	.104	.1058	.0025	.0025	.0020	.0010	.0025	.0030
Q802	.108	.106	.1072	.0015	.0020	.0025	.0025	.0035	.0065
Q803	.108	.104	.1063	.0025	.0040	.0030	.0030	.0025	.0015
Q804	.108	.104	.1061	.0020	.0030	.0030	.0015	.0025	.0065
Q805	.108	.105	.1067	.0030	.0020	.0010	.0015	.0040	.0015
Q806	.107	.105	.1060	.0010	.0020	.0030	.0020	.0015	.0010
Q807	.106	.102	.1039	.0015	.0040	.0030	.0020	.0020	.0035
Q808	.109	.102	.1046	.0030	.0060	.0065	.0010	.0080	.0060
Q809	.108	.105	.1069	.0015	.0030	.0020	.0020	.0020	.0085
Q810	.106	.104	.1053	.0020	.0015	.0030	.0010	.0035	.0070
Q811	.107	.103	.1048	.0015	.0040	.0030	.0030	.0020	.0050
Q812	.107	.103	.1052	.0010	.0040	.0040	.0015	.0015	.0030
Q813	.108	.105	.1068	.0025	.0030	.0025	.0015	.0050	.0060
Q814	.108	.103	.1058	.0020	.0040	.0030	.0025	.0030	.0030
Q815	.107	.103	.1051	.0025	.0035	.0035	.0015	.0055	.0070
Q816	.107	.102	.1050	.0030	.0050	.0025	.0020	.0055	.0100
Q817	.109	.105	.1068	.0015	.0030	.0025	.0015	.0025	.0070
Q818	.107	.103	.1051	.0020	.0040	.0040	.0015	.0010	.0035
Q819	.105	.102	.1038	.0020	.0025	.0030	.0010	.0020	.0050
Q820	.106	.104	.1056	.0025	.0020	.0025	.0010	.0055	.0065
Q821	.108	.106	.1071	.0005	.0010	.0020	.0010	.0015	.0035
Q822	.108	.104	.1062	.0015	.0030	.0030	.0020	.0035	.0035
Q823	.109	.103	.1063	.0040	.0030	.0035	.0010	.0030	.0035
Q824	.108	.103	.1050	.0040	.0030	.0035	.0010	.0055	.0055
Q825	.106	.104	.1054	.0020	.0020	.0020	.0020	.0045	.0035
Q826	.108	.104	.1064	.0015	.0035	.0035	.0015	.0045	.0040
Q827	.106	.104	.1049	.0010	.0020	.0040	.0010	.0025	.0065
Q828	.106	.102	.1046	.0040	.0040	.0045	.0020	.0035	.0015
Q829	.108	.105	.1064	.0010	.0030	.0020	.0020	.0040	.0045
Q830	.108	.105	.1064	.0020	.0030	.0030	.0020	.0045	.0050
Q831	.108	.105	.1066	.0020	.0020	.0020	.0015	.0035	.0010
Q832	.108	.102	.1052	.0050	.0030	.0040	.0015	.0015	.0020
Q833	.109	.105	.1074	.0040	.0020	.0030	.0010	.0025	.0045
Q834	.107	.105	.1061	.0020	.0020	.0020	.0010	.0050	.0060
Avg.	.1075	.1039	.1058	.0020	.0030	.0029	.0014	.0033	.0061
Std. Dev.	±.0009	±.0011	±.0008	±.0009	±.0008	±.0014	±.0006	±.0015	±.0029
Specifications:									
	.105	.100	--	.0020	.0060	.0060	.0060	.0030	.0030

Notes:

1. Variation in straightness or thickness of wall shall not exceed .006 in any axial plane.
2. Variation of wall thickness in any transverse plane shall not exceed .002.
3. The indicated measurement at each datum is the total indicator runout of the liner's outside surface relative to the register diameter. The difference between the runout at the two datum planes is an indication of the lack of perpendicularity of the register plane and the liner axis.
4. Lower datum is .484 inch above the base; upper datum 3.202 inches above base.

Table IX
Penetration Data
DRB398 Machined Cones — Effect of Standoff

Round No.	Lbs. Comp B	Standoff (inches)	Penetration inches M.S.	Max. Spread (in.)	Std. Dev. (in.)
FS627	2.58	4.0	18.19		
FS628	2.58	"	18.50		
FS629	2.58	"	18.50		
FS630	2.56	"	18.19		
FS631	2.58	"	18.56		
			Avg. 18.39	0.37	±.18
FS632	2.58	7.5	19.94		
FS633	2.58.	"	20.56		
FS634	2.60	"	19.56		
FS635	2.58	"	19.12		
FS636	2.58	"	20.50		
			Avg. 19.93	1.44	±.62
FS637	2.58	15.0	21.88		
FS638	2.56	"	20.75		
FS639	2.58	"	20.81		
FS640	2.58	"	22.31		
FS641	2.58	"	21.75		
			Avg. 21.50	1.56	± 69
FS642	2.60	22.5	19.81		
FS643	2.58	"	22.25		
FS644	2.60	"	21.69		
FS645	2.58	"	22.00		
FS646	2.58	"	20.62		
			Avg. 21.27	2.44	±1.03

Notes:
1. Cones assembled in DRC376 test bodies with nose rings.
2. All rounds were fired at Erie Ordnance Depot at 0 rev/sec.
3. Rounds loaded at Ravenna Arsenal, BAT Lot No. 23 with Composition B, Holston Lot 3-126.

Table X
Penetration Data
DRB398 Pressed Cones — Effect of Standoff

Round No.	Lbs. Comp B	Standoff (in.)	Penetration (inches M.S.)	Max. Spread (in.)	Std. Dev. (in.)
FS851	2.58	4.0	19.31		
FS852	2.58	"	19.38		
FS853	2.60	"	19.18		
FS854	2.58	"	18.25		
FS855	2.60	"	18.19		
			Avg. 18.86	1.19	±0.59
FS856	2.58	7.5	21.00		
FS857	2.58	"	18.94		
FS858	2.60	"	22.18		
FS859	2.58	"	19.38		
FS860	2.58	"	19.38		
			Avg. 20.18	3.24	±1.37
FS861	2.56	15.0	22.25		
FS862	2.56	"	19.31		
FS863	2.58	"	22.06		
FS864	2.56	"	23.18		
FS865	2.60	"	20.31		
			Avg. 21.42	3.87	±1.57
FS866	2.58	22.5	18.06		
FS867	2.58	"	18.25		
FS868	2.58	"	23.75		
FS869	2.58	"	21.62		
FS870	2.60	"	20.44		
			Avg. 20.42	5.69	±2.39

Notes:
1. Cones assembled in DRC376 test bodies with nose rings.
2. All rounds were fired at Erie Ordnance Depot at 0 rev/sec.
3. Rounds loaded at Ravenna Arsenal, BAT Lot #22 with Composition B, Holston Lot 3-126.

Effect of Tee Configuration

Further studies of the effect of internal configuration of the tee upon penetration were conducted. Fig. 5 shows the DRC314 tee and the two modifications studied. The penetration data are shown in Table XI. The average penetration of the DRB 398 drawn cones fired with DRC314 tees is 16.01 inches. (Table VI, Twenty-Seventh Progress Report). The DRC314 HW10 tee allows 16.2 inches and the DRC 314 HW14 tee 18.24 inches. The principal difference between these two modifications is that the DRC314HW14 tee allows approximately .25 inch more space in front of the cone than does the DRC314 HW10. It now seems that of the several tee modifications tested the DRC314 HW11 tee (Twenty-Seventh Progress Report) and the DRC314 HW14 cause the least reduction in penetration.

Comp B Loading; Effect of Riser Material

Ten rounds, with DRB398 cones and DRC376 bodies, were poured using two different types of pouring funnels or risers to determine the effect upon penetration performance. The basic design of the two risers is similar, as shown in Fig. 6 but one is made of aluminum, the other of glazed chemical porcelain. The greater thermal conductivity of aluminum makes the center hole necessary to prevent premature freezing off of the charge. The center hole is not necessary with porcelain risers. Charges poured using porcelain risers show some surface discoloration (yellowing) of the Composition B where it contacts the porcelain. This test was undertaken to determine whether the difference in risers and consequent rate of cooling, etc. has an effect upon

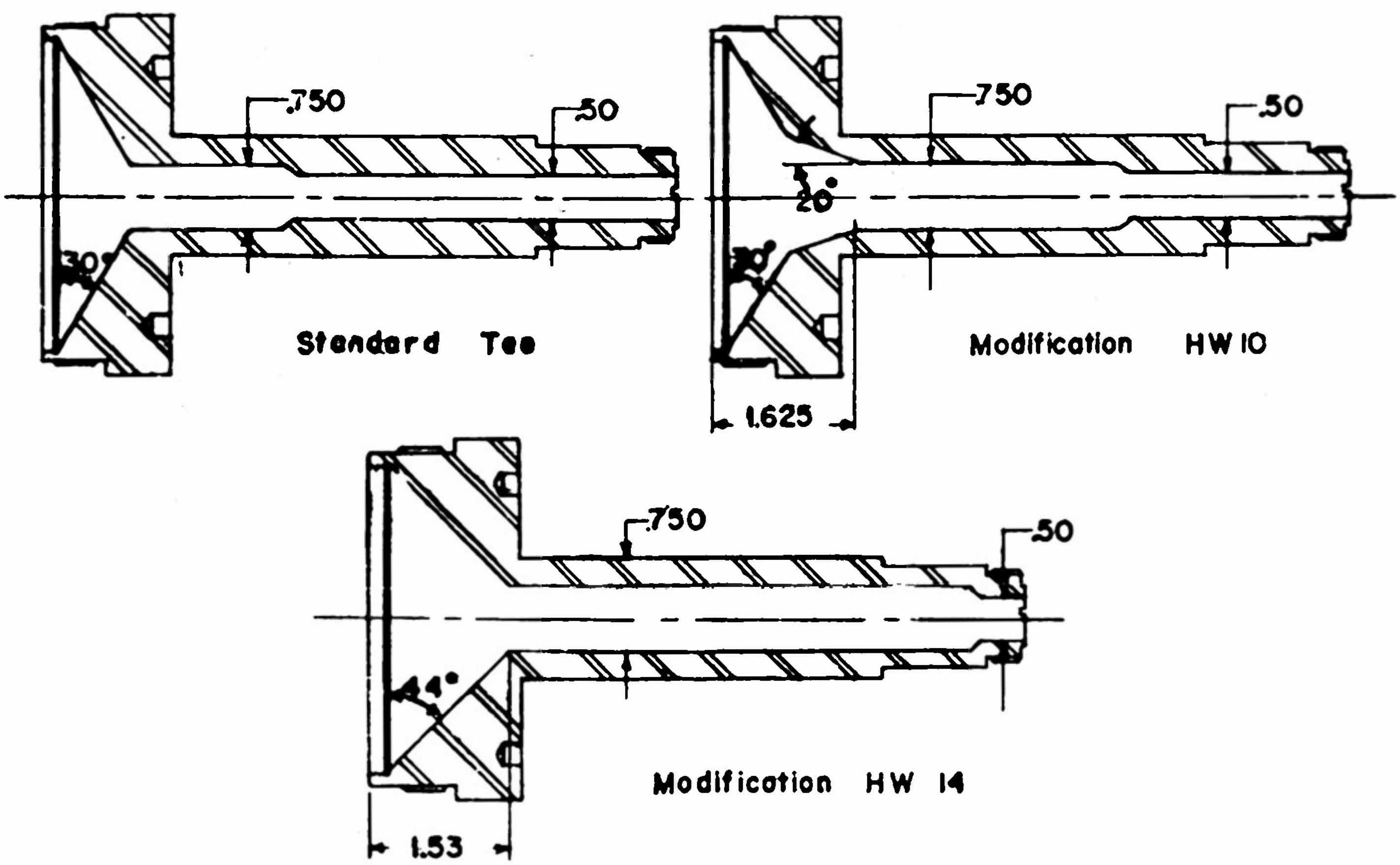

Fig. 5. DRC314 Tee and Two Modifications.

penetration. The penetration data are shown in Table XII. The charges cast using aluminum risers penetrated about 5% (1.0 inch) more than did the others.

Malleable Iron Tees

T138 projectiles have a long slender tee or boom which usually enters the cavity created by the shaped charge jet and effectively seals the hole. It has never been determined whether this is desirable or undesirable. To see whether a tee made of a material more brittle than mild steel would break up instead of plugging the cavity, tests with two types of malleable iron have been conducted. One type is made of malleable iron having an elongation at break of from 16% to 20%, the other is made of manganese enriched malleable iron having an elongation at break of from 5% to 8%. All tees are made to drawing DRC314-16 except for material. The penetration data are shown in Table XIII. No differences between the performances of these two types of malleable iron and mild steel were observed.

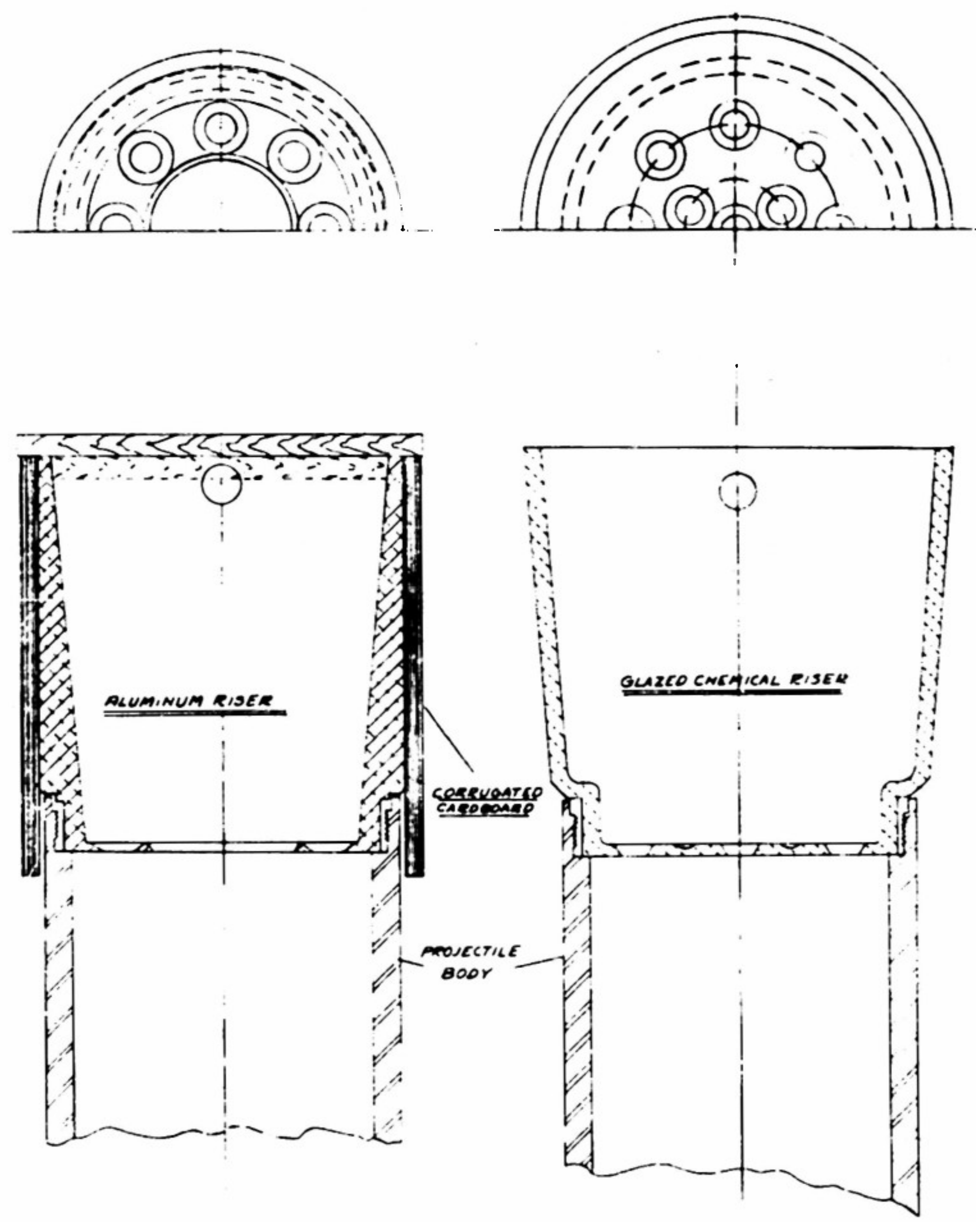

Fig. 6. Two Types of Risers.
For Loading High Explosives.

Table XI
Penetration Data
With DRC314 HW10 Tee

Round No.	Lbs. Comp B	Rev/Sec	Penetration (in.)	Max. Spread (in.)	Std. Dev. (in.)
(With DRC314 HW10 Tee)					
Q745	2.56	0	19.12		
Q746	2.58	"	13.94		
Q757	2.58	"	14.62		
Q758	2.58	"	16.75		
Q775	2.58	"	16.56		
			Avg. 16.20	5.18	±2.03
(With DRC314 HW14 Tee)					
Q747	2.60	0	18.06		
Q748	2.56	"	18.62		
Q749	2.58	"	19.12		
Q750	2.58	"	16.88		
Q751	2.58	"	18.50		
			Avg. 18.24	2.24	±.85

Notes:
1. DRC376 bodies and plugs; booster in base plug.
2. Loaded at Ravenna Arsenal, BAT Lot #21 (HW10), BAT Lot #23 (HW14), with Composition B, Holston Lot 3-126.
3. All rounds fired at Erie Ordnance Depot.

Table XII
Penetration Data
Effect of Riser Type

Round No.	Lbs. Comp B	Rev/Sec	Penetration (in. M.S.)	Max. Spread (in.)	Std. Dev. (in.)	Remarks
Q735	2.54	0	20.00			Al. Riser
Q736	2.54	"	18.56			" "
Q739	2.56	"	20.56			" "
Q742	2.56	"	19.18			" "
Q743	2.58	"	20.75			" "
			Avg. 19.81	2.19	±0.93	
Q737	2.54	0	18.75			Porcelain
Q738	2.56	"	20.75			"
Q740	2.56	"	17.38			"
Q741	2.56	"	19.06			"
Q766	2.60	"	18.50			"
			Avg. 18.89	3.37	±1.22	

Notes:
1. Assembled in DRC376 test bodies with nose rings.
2. Loaded at Ravenna Arsenal, BAT Lot #21 with Composition B, Holston Lot 3-126.
3. All rounds fired at Erie Ordnance Depot at 7.5" standoff.

Table XIII
Penetration Data
Tee Material Study

Round No.	Lbs.Comp.B	Type Tee	Penetration (inches M.S)	Max. Spread (in.)	Std. Dev. (in.)	Remarks
0752	2.58	Reg. Malleable Iron	13.94			Tee in target
0753	2.62	" " "	17.12			" " "
0754	2.60	" " "	17.81			" " "
0755	2.60	" " "	16.81			Tee not in target
0756	2.58	" " "	11.94			" " " "
			Avg. 15.52	5.87	±2.49	
0759	2.62	High Manganese	14.31			Tee in target
0760	2.64	" "	16.69			" " "
0772	2.61	" "	17.31			" " "
0773	2.60	" "	15.38			" " "
0774	2.60	" "	17.94			" " "
			Avg. 16.33	3.63	±1.47	

Notes:
1. Assembled in DRC376 test assemblies.
2. Loaded at Ravenna Arsenal, BAT Lot No. 20 with Comp B, Holston Lot 3-126.
3. All rounds fired at Erie Ordnance Depot at 0 rev/sec.
4. Standoff is 7.32 in.

Explosive Train and Detonator Safety Tests On T222E5 Base Elements

Sixteen base elements, DRD328, (Fig. 10 of the Twenty-Fifth Progress Report) were modified to bring the leads of an M36 detonator out of the rear of the base element, with the rotor in the armed position. M36 detonators were substituted for T18 detonators for safety in handling. Each base element had one tetryl lead (PA-E-11458) and one tetryl pellet (PA-E-11459). The loaded and armed base elements were mounted in T138 base plugs (DRB410), as shown in Fig. 7, and were placed tetryl end down on witness plates of 3/4-in. homogeneous armor plate and fired in the penetration chamber at Erie Ordnance Depot. Fifteen of these assemblies were initiated using a 1.5-volt flashlight battery and gave high order detonations; the other failed to function high order. Fig. 8 is a photograph of the witness plate.

For comparison, the center hole, with the added crater, shown in Fig. 8, was produced by two P82466 pc mk C tetryl pellets fired by an M36 detonator placed in the center hole of the pellets. The crater was probably produced either by the M36 detonator or by the cavity (shaped charge) effect of the hole in the tetryl pellets.

To test the detonator safety of T222E5 base elements (DRD328), two base elements were fired as described above, using M36 detonators, tetryl leads (PA-E-11458) and tetryl pellets (PA-E-11459) except that the rotor was in the unarmed position. The detonator in each assembly was heard to explode but no external marks were apparent. The base elements were not disassembled for inspection; they were destroyed by firing with tetryl pellets placed on the outside.

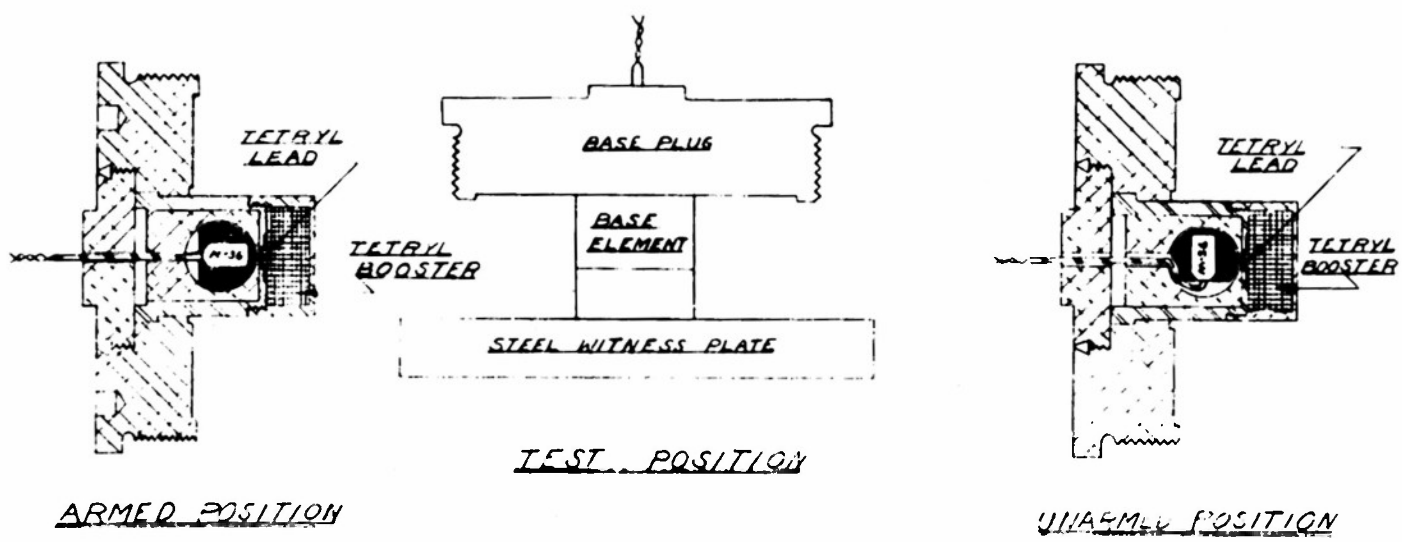

Fig. 7. Base Element Test Assembly.

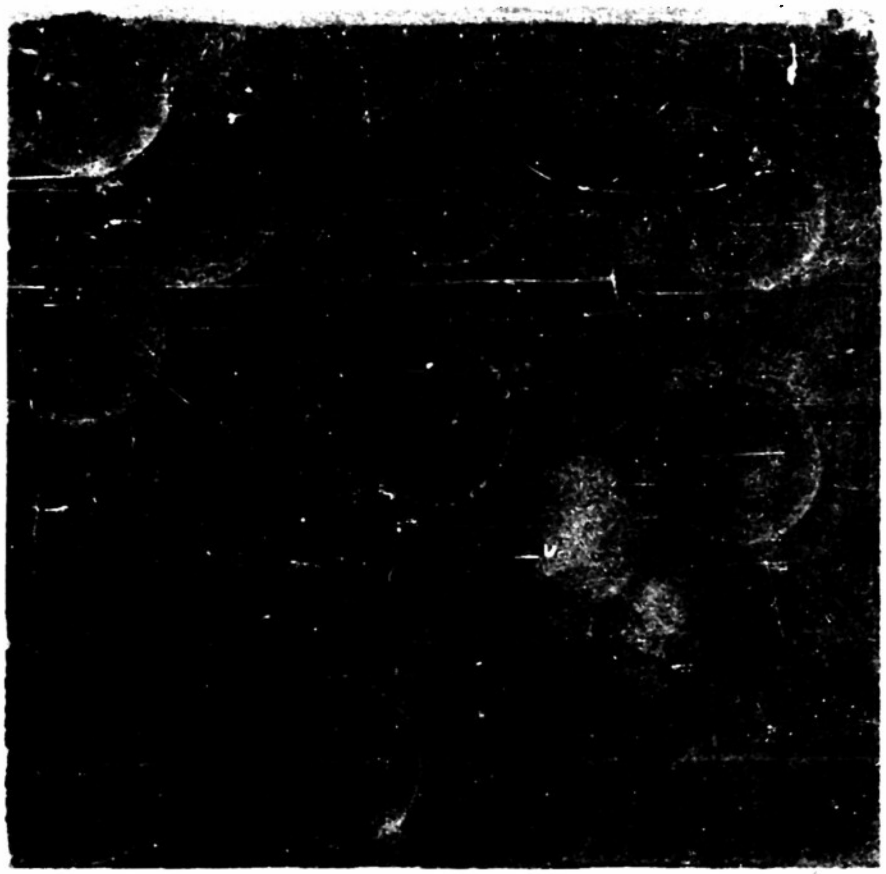

Fig. 8. Photograph of Witness Plate.

Comparison of T222E5 and T208E5 Base Elements for Explosive Train Effectiveness

Five T222E5 base elements (DRD328) and five T208E5 base elements were fired to compare the brisance effect on 3/4-in. homogeneous armor plate. Both types of base elements were equipped with M36 rather than T18 detonators and were modified as shown in Fig. 7 to bring the leads out through the base. The T222E5 base elements had PA-E-11458 tetryl leads and PA-E-11459 tetryl pellets. The T208 E5 base elements had their standard tetryl pellets, but no tetryl lead pellets or cups. Two T208E5 base elements gave high order performances, two gave somewhat poorer performance and one resulted in a low order detonation. All five T222 E5 base elements gave high order performances. Fig. 9 and Fig. 10 show the depressions produced in the armor plate.

DRC439 Fuzing System

Five penetration assemblies as shown in Fig. 11, including the elements of a DRC439 fuzing system, were prepared. These assemblies were loaded at Ravenna Arsenal and fired at Erie Ordnance Depot. Table XIV shows the results of this penetration study.

Comparison of these data with those of standard penetration assemblies (Item IIa, Table VI, Twenty-Seventh Progress Report) indicates that the performance is satisfactory. Use of this fuzing system simplifies the loading and handling of HEAT rounds because the base elements are plugged into place thereby eliminating the necessity of protecting the lead wire during loading of the shell and of attaching the lead wire to the terminal on the base element.

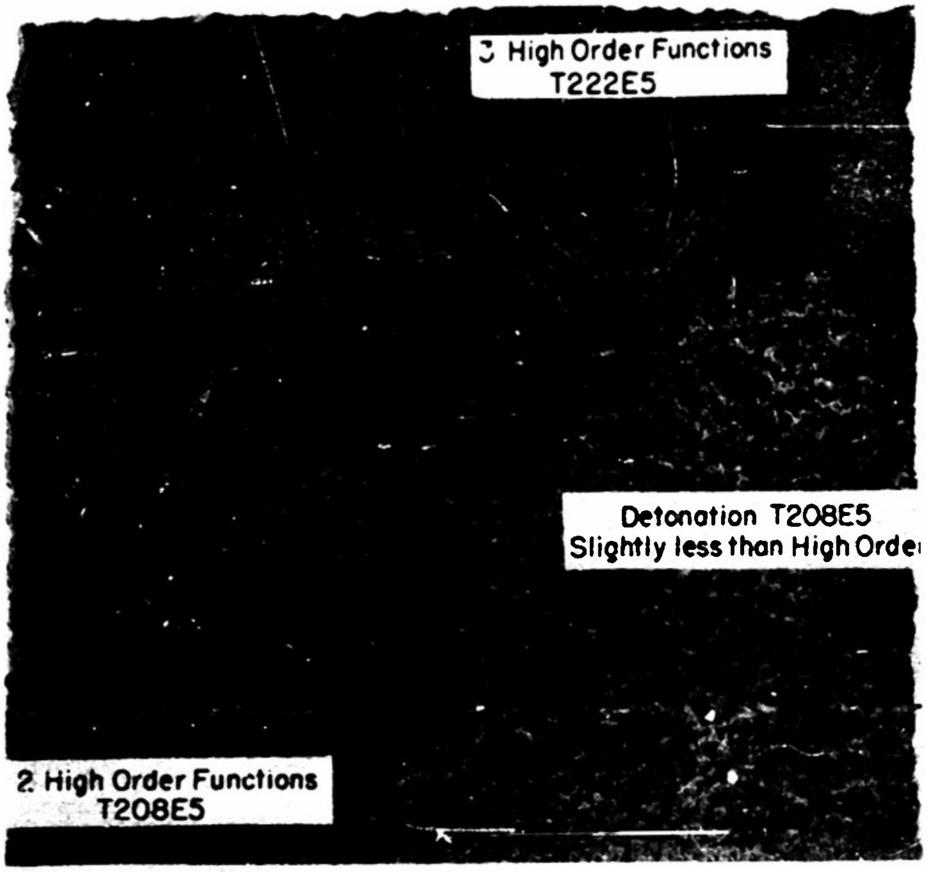

Fig. 9. Depressions in Armor Plate.

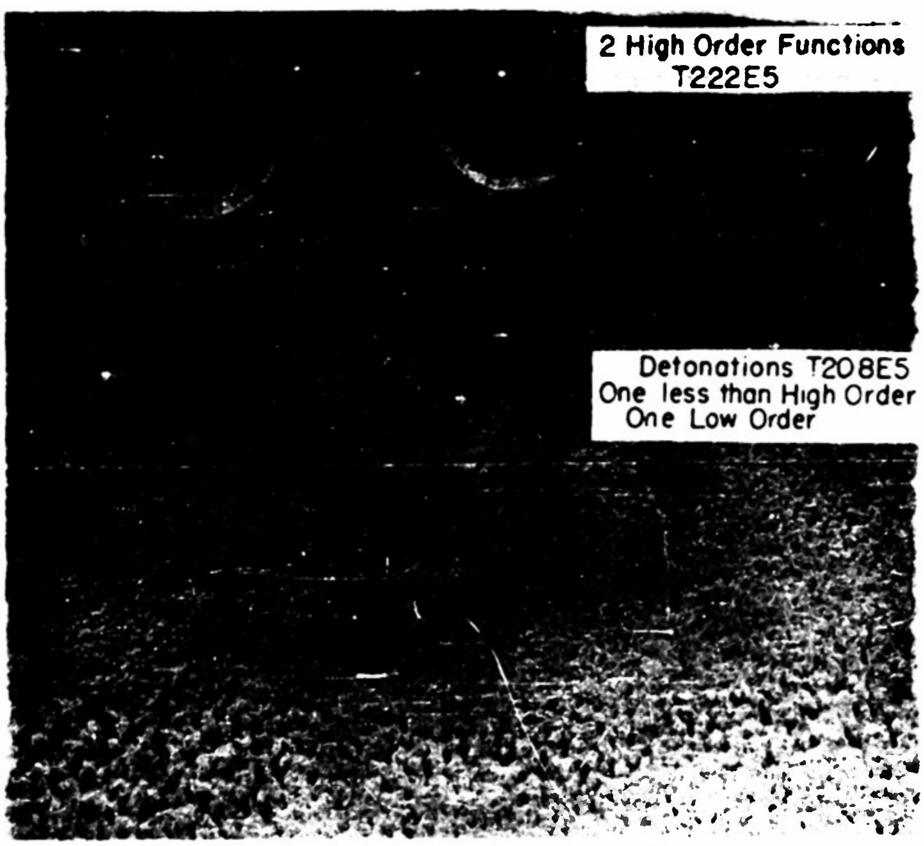

Fig. 10. Depressions in Armor Plate.

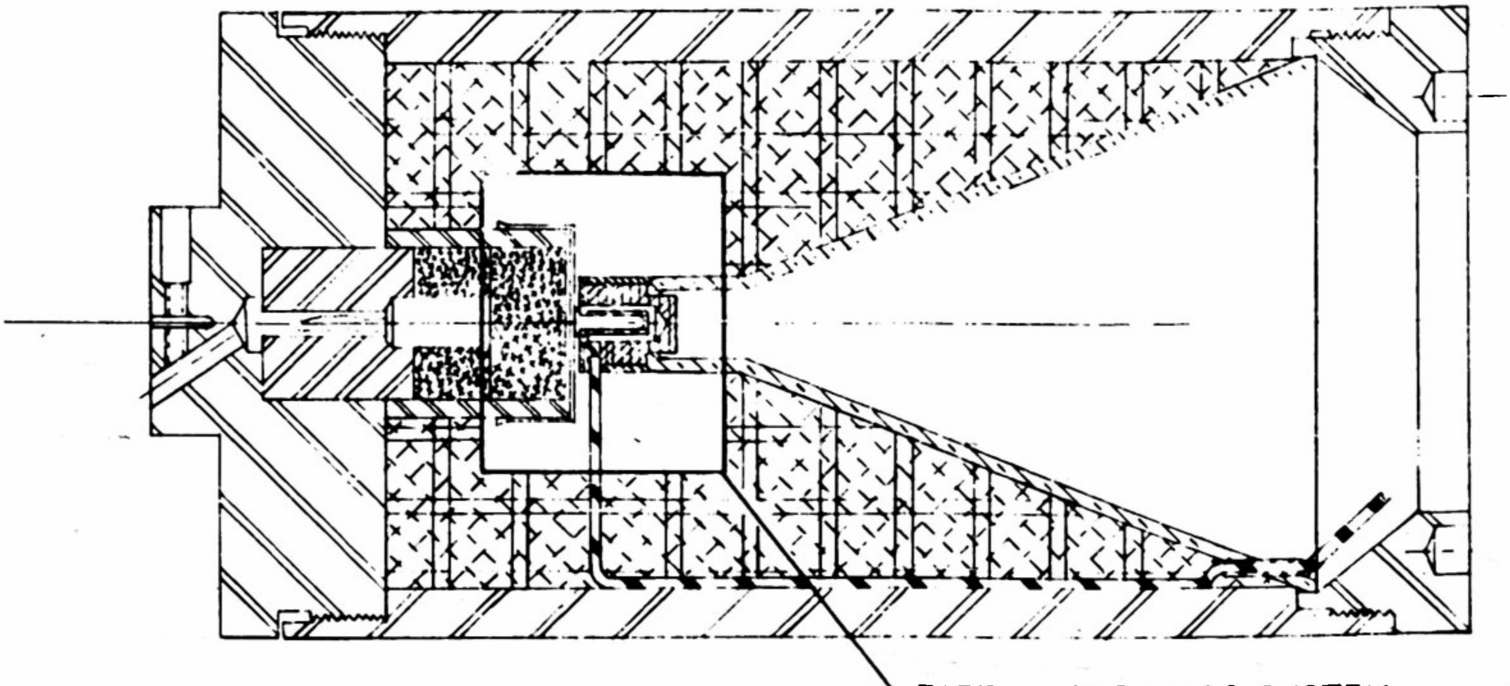

Fig. 11. Penetration Assembly.

Table XIV
Penetration of Rounds Using DRC439 Fuzing System

Round No.	Spin Rate (rev/sec)	Standoff (in.)	Penetration (in.)
FS846	0	7.5	20.44
FS847	0	7.5	19.38
FS848	0	7.5	18.50
FS849	0	7.5	18.31
FS850	0	7.5	19.88
			Avg. 19.30